A WISE Observation of a coolest brown dwarf, CFBDSIR 1458+1013.

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ABSTRACT

The Wide-field Infrared Survey Explorer (WISE) has detected the close binary brown dwarf system CFBDSIR 1458+1013AB as WISEP J145829.35+101341.8 with a combined magnitude at 4.6 μm of W2 = 15.488 ± 0.147. This allows a comparison with another "coolest" brown dwarf candidate WD 0806-661B that has been observed at 4.5 μm with [4.5] = 16.75 ± 0.05. Here we use the WISE data to show that 1458+1013B is almost certainly warmer and more luminous than WD 0806-661B.

Subject headings: stars: low-mass, brown dwarfs; infrared radiation

1. Introduction

The Wide-field Infrared Survey Explorer (WISE) (Wright et al. 2010) has surveyed the entire sky in four thermal infrared bands. The Spitzer 4.5 μm band and the WISE 4.6 μm (W2) band are very similar in wavelength, so no large color term is expected when comparing magnitudes in these bands. We have examined the set of spectroscopically confirmed T dwarfs seen by both WISE and Spitzer and see only a small color term, with mean [4.5]-W2 = 0.054 magnitudes and no apparent trend with color or spectral type.

We can use this to estimate the W2 magnitude of WD 0806-661B to be 16.7 based on the Spitzer data (Luhman et al. 2011), which is below the sensitivity limit for WISE. Given the 1.25 μm limit of J > 21.7 (Rodriguez et al. 2011), the color is J-W2 > 5.0. With the 19.2 ± 0.6 pc distance (Luhman et al. 2011), the absolute magnitude is $M_{W2} = 15.28$.

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2. Color-Magnitude Fit

The WISE data on the close binary 1458+1013 only give the combined light at 4.6 μm, with a W2 magnitude of 15.488 ± 0.147. The other WISE bands only give upper limits on the flux, with a 2σ limit on the combined magnitude at 3.4 μm of W1 > 16.84 magnitudes. The brightness of the secondary component of the binary depends on the assumed flux ratio $f = F_A/F_B$. This ratio is 5.2, 8.6 & 7.6 at 1.25, 1.6 & 2.15 μm (Liu et al. 2011), but we expect the B component of the binary will be redder than the A component leading to a lower flux ratio at 4.6 μm. We have estimated the flux ratio at 4.6 μm by fitting a straight line $M_{W2} = a + b(J - W2)$ to a sample consisting of brown dwarfs with known distances (Patten et al. 2006) plus the A and B components of 1458+1013 with the flux ratio f as a third parameter of the fit. Figure 1 shows the best fit, which has $a = 11.14$ and $b = 0.701$. The scatter is larger than can be explained by observational errors, so the error on f from the fit is calculated assuming a intrinsic scatter of ±0.42 on M_{W2}. This gives a flux ratio $f = 1.85 \pm 0.61$. For the best fit flux ratio 1458+1013B is as red as the lower limit on the color for WD 0806-661B, but also considerably more luminous at 4.6 μm. For larger flux ratios the B component gets fainter but also bluer. If

the straight line fit to M_{W2} to $(J-W2)$ were exact then $f(W2) = f(J)^{b/(1+b)} = 1.97$. For this flux ratio the color of 1458+1013B is J-W2 = 5.01 and the absolute magnitude is $M_{W2} = 14.85$, insignificantly different from the plotted solution.

3. Discussion

Given that WD 0806-661B is both 20% closer to the Sun and its flux is 3 times fainter than the combined light of 1458+1013 at 4.6 μm, our conclusion that WD 0806-661B is the cooler and less luminous of these two "coolest" brown dwarfs is straightforward. The same conclusion can be made in the J band where the Rodriguez et al. (2011) limit on WD 0806-661B is fainter than the measured magnitude of 1458+1013B (Liu et al. 2011). This conclusion is also reflected in the estimated effective temperatures: 370 ± 40 K for 1458+1013B (Liu et al. 2011) and ≈ 300 K for WD 0806-661B (Luhman et al. 2011). But the fitted line predicts that the color of WD 0806-661B is J-W2 = 5.9 ± 0.6. If this prediction is correct then the apparent J magnitude of WD 0806-661B will be J = 22.6, and followup spectroscopy to confirm that this object is a brown dwarf will be impossible using ground-based telescopes and quite difficult even with the Hubble Space Telescope. The WISE all-sky survey should find objects this red and redder that are much closer to the Sun and thus much more suited for detailed study.

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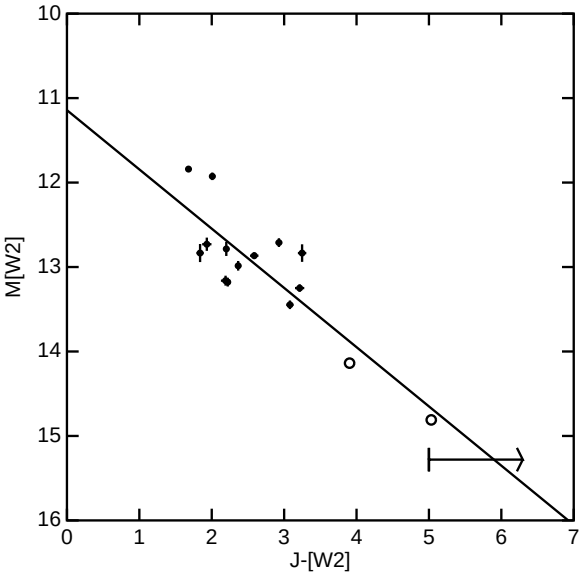

Fig. 1.— A color magnitude diagram for T brown dwarfs. The solid points with errorbars are T dwarfs (Patten et al. 2006) while the open circles are 1458+1013 A & B with the flux ratio derived in the fit. The rightward arrow in the lower right shows WD 0806-661B (Luhman et al. 2011; Rodriguez et al. 2011)

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